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CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

Point de l'ordre du jour : D.1.3

France

LE PROBLEME DE LA CIMENTERIE, AU REGARD DES BESOINS DE LA CONSTRUCTION, DANS LES PAYS EN VOIE DE DEVELOPPEMENT

Par Henri LAFUMA,
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Paris

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

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LE PROBLEME DE LA CIMENTERIE, AU REGARD DES BESOINS DE LA CONSTRUCTION, DANS LES PAYS EN VOIE DE DEVELOPPEMENT

Henri LAFUMA

Directeur du Centre d'Etudes et de Recherches
de l'Industrie des Liants Hydrauliques (Paris)

1.-

(a) A l'aube de leur industrialisation, les pays en voie de développement manifestent le désir de voir installer, sur leur territoire, une cimenterie, une sucrerie et une papeterie. C'est que le ciment est en quelque sorte le symbole de la construction, comme le sucre peut être considéré comme le symbole d'une alimentation évoluée et le papier le symbole de l'expression de la pensée. Le problème du vêtement ne vient qu'ensuite peut-être parce que mieux résolu en l'absence de techniques industrielles.

(b) Dans les pays industrialisés où l'on voit depuis quelques années, la consommation, et donc la production de ciment, croître rapidement, la capacité de l'unité moyenne a crû parallèlement. De 100 000 tonnes/an environ, il y a une quinzaine d'années en France, la capacité de production de la cimenterie moyenne est passée à 250 - 300 000 t/an, avec tendance à poursuivre l'augmentation. Naturellement les conceptions du matériel moderne ont évolué selon cette tendance, en mettant au premier rang des préoccupations la recherche des économies de main-d'oeuvre et d'énergie. Une productivité de deux heures de main-d'oeuvre, à la tonne produite, était il y a quelques années jugée satisfaisante, et elle reste encore souvent à ce niveau; mais dans les usines récentes la main-d'oeuvre est inférieure à une heure à la tonne produite.

(c) Bien entendu ce n'est pas dans cette perspective qu'il faut situer le problème de la cimenterie dans les pays en voie de développement, sauf cas particuliers, probablement exceptionnels : on peut citer, par exemple, la cimenterie de Rufisque, près de Dakar, dont la production est passée de 80 000 tonnes en 1954, à 176 000 tonnes en 1960, dont les trois quarts sont vendus au Sénégal, et dont la capacité de production actuelle est de l'ordre de 200 000 t/an, suffisante pour satisfaire la consommation potentielle du pays.

(i) Même dans ces conditions, le problème ne se pose pas sur le plan d'une main-d'oeuvre rare; il y a quelques années, demandant à un technicien japonais quelle était la productivité main-d'oeuvre de la cimenterie japonaise, il nous fut répondu qu'elle devait être sensiblement le tiers de la productivité de la cimenterie française : le problème, à l'époque, n'était pas d'avoir une productivité élevée, mais de donner du travail à trois fois plus d'ouvriers.

a Il est certain que, dans les pays où la consommation potentielle est inférieure à 80 - 100 000 t/an, on ne saurait envisager l'installation d'une cimenterie moderne, et même d'une simple cimenterie dans les pays où la consommation potentielle est inférieure à 30 000 t/an (chiffre correspondant à la production d'un seul four droit de 100 tonnes/jour). C'est d'ailleurs avec une telle production que les premières réalisations des pays d'Asie et d'Afrique, en voie d'industrialisation, ont presque toutes débuté.

2.-

(a) Ces considérations, même très schématiques, auront montré l'importance primordiale de la consommation potentielle pour décider de l'implantation d'une cimenterie : ici, comme ailleurs, c'est bien entendu le débouché qui commande la décision et, pour être plus explicite, nous examinerons la situation des pays en voie de développement de l'Afrique Noire francophone en empruntant les éléments chiffrés (1962) qui suivent à un rapport récent de M. GUILLAUMET, directeur de CIMFRANCE, sur les possibilités techniques et la capacité des marchés d'Afrique Noire.

(i) Le cas du Sénégal a déjà été envisagé. La consommation potentielle du Soudan est difficile à déterminer, vraisemblablement comprise entre 20 et 30 000 t/an. La consommation potentielle de la Côte d'Ivoire serait comprise entre 170 et 200 000 t/an; on pourrait donc envisager l'installation d'une cimenterie moderne, mais il ne semble pas qu'il y ait de carrière de calcaire possible. Le pays pourrait se satisfaire d'une station de broyage, mais les frêts actuels sont tellement bas qu'aucune économie sur ce chapitre n'est possible.

(ii) La consommation potentielle de la Haute-Volta serait de l'ordre de 15 à 30 000 t/an; celle du Togo de l'ordre de 35 à 40 000 t/an; celle du Dahomey de 60 000; celle du Niger de 15 à 20 000.

(iii) La consommation potentielle du Cameroun serait comprise entre 70 et 90 000 t/an; celle du Gabon d'environ 30 000, un projet de chemin de fer permettant de penser qu'elle atteindrait 40 à 50 000 t/an; enfin la consommation potentielle du Congo serait de 60 000 t/an, pouvant dépasser 100 000 si le barrage de KOVILOU et son complexe se réalisent.

a On voit que, dans certains cas, le débouché potentiel justifierait l'implantation d'une cimenterie moderne. Et même, entre différents pays, isolément trop faibles consommateurs, une entente donnerait un ensemble dont la consommation potentielle serait suffisante : c'est le cas de l'ensemble Togo - Dahomey - Niger dont la consommation potentielle est supérieure à 100 000 t/an.

b En tout cas, l'implantation d'une cimenterie de 100 000 t/an suppose un marché susceptible d'absorber la production de l'usine dans un rayon de 500 à 1 000 km suivant que l'on dispose de routes, chemins de fer ou voies d'eau.

3.-

(a) Un tel marché suppose une région ayant atteint déjà un certain niveau d'industrialisation et il importe peu alors que l'unité implantée n'occupe, en raison de sa productivité élevée, qu'une main-d'oeuvre très réduite : c'est en aval, au stade de l'utilisation du ciment, que les emplois se multiplient.

(i) Encore faut-il que les conditions géologiques nécessaires soient remplies : en Côte d'Ivoire, comme il a été signalé, il ne semble pas qu'il y ait actuellement de carrière de calcaire susceptible de satisfaire une consommation potentielle voisine de 200 000 t/an.

a Mais si les conditions techniques sont remplies, le problème de la cimenterie se pose très sensiblement de la même manière que dans les pays industrialisés et le facteur prépondérant qu'il convient d'envisager est la possibilité d'engager les investissements très élevés d'une cimenterie moderne, de l'ordre de quatre à cinq ans de chiffre d'affaires, en France. Pour que le projet soit sain, il faut que le prix de vente du ciment fabriqué, charges fiscales et marge bénéficiaire comprises, ne soit pas supérieur au prix de revient actuel du ciment importé et cela, sans protection douanière; il importe, au surplus, que la production locale soit efficacement protégée contre le dumping ou la pratique trop fréquente de prix anormalement bas, le marché de l'exportation du ciment se resserrant de plus en plus.

4.-

(a) C'est en somme pour les consommations potentielles nettement inférieures, comprises entre 30 et 80 000 t/an, d'ailleurs les plus fréquentes, que se pose le problème le plus difficile de la cimenterie dans les pays en voie de développement. L'intitulé de cette communication " au regard des besoins de la construction " signifie simplement que la cimenterie locale doit satisfaire aux besoins courants, c'est-à-dire produire des ciments pour l'usage général, béton et béton armé, ordinaires, travaux de maçonnerie. Il ne saurait être question de réaliser des performances : supercinent pour béton précontraint par exemple. Les ciments spéciaux, dont le besoin peut être réel mais très limité, resteront du domaine de l'importation. Disons de suite, et pour n'y plus revenir, qu'il en est de même pour les plus faibles consommations potentielles inférieures à 25 000 t/an de ciment ordinaire et nous nous en tiendrons maintenant aux consommations potentielles moyennes précisées ci-dessus.

5.-

(a) Les facteurs qui conditionnent l'implantation d'une petite cimenterie sont si nombreux et divers que chaque cas particulier pose un problème complexe. Ces facteurs sont essentiellement géologiques, géographiques, financiers, économiques et techniques.

(i) La première condition pour la mise en route d'une cimenterie est évidemment la présence d'un gisement de calcaire convenable en qualité et en quantité, en supposant que l'on trouve à proximité l'argile, ou son équivalent, nécessaire pour corriger la composition. Si l'on trouve en France des calcaires convenables un peu partout, à l'exception toutefois de la Bretagne et du Massif Central, il n'en est pas de même en tous pays.

(ii) C'est ainsi qu'au Soudan les calcaires reconnus sont souvent trop magnésiens et géographiquement mal situés. Calcaires magnésiens également en Haute-Volta. Au Dahomey, le gisement de calcaire d'Arlan permettrait à une cimenterie de 50 000 t/an de fonctionner pendant une dizaine d'années et ne permettrait probablement pas d'amortir l'installation. Au Cameroun, la consommation se situe dans le Sud où l'on n'a pas reconnu, jusqu'à présent, de gisement de calcaire exploitable.

a Ces exemples illustrent l'importance des facteurs géologiques et géographiques; parfois l'importance des facteurs économiques et financiers lui est comparable.

b D'une manière générale l'évolution économique favorise l'implantation de cimenteries locales, car l'exportation du ciment ordinaire apparaît de plus en plus anachronique. A différentes reprises, on a même d'ailleurs constaté que la création d'une première cimenterie avait, comme première conséquence, momentanée il est vrai, l'augmentation initiale imprévue du tonnage de ciment importé dans le pays considéré. Mais il est nécessaire, là encore, que la production soit protégée contre le dumping et les prix marginaux trop bas possibles pour les pays dont l'industrie cimentière est suréquipée.

(i) Les facteurs financiers prépondérants sont assurément les possibilités d'investissement et d'amortissement. Il a été indiqué que les investissements d'une cimenterie moderne étaient très coûteux, de l'ordre de 200 à 250 NF la tonne/an, pour un produit vendu, hors taxe, de 50 à 60 NF la tonne. Ces investissements permettent de réduire les frais de main-d'oeuvre, ce qui est actuellement un impératif primordial dans les pays industrialisés où se fait sentir le manque de main-d'oeuvre. Il n'en est bien entendu pas de même dans les pays en voie de développement où l'on dispose d'une abondante main-d'oeuvre, souvent peu qualifiée il est vrai. Mais si le matériel et les produits les plus modernes demandent une haute technicité, il n'en est pas nécessairement de même d'une cimenterie à l'image de celle qu'ont connue nos grands pères et dont on trouve encore quelques spécimens -en voie de disparition d'ailleurs- dans des pays cependant très industrialisés.

6.-

(a) Et c'est bien, à notre avis, en tirant le meilleur parti des techniques plus rudimentaires de la cimenterie ancienne que l'on peut apporter, aux pays en voie de développement, l'aide la plus efficace, la formation technique d'une main-d'oeuvre plus nombreuse devant être au premier rang des préoccupations. Cette éducation est moins difficile si l'on ne vise pas immédiatement à une très haute technicité et il en est de même d'ailleurs en ce qui concerne les

produits élaborés; on peut à cet égard facilement distinguer, pour les besoins de la construction, trois tendances nettement différentes dans le choix des produits à utiliser :

(b) - une première tendance répondant aux techniques encore artisanales, et toujours assez répandues, comme celles de la maçonnerie;

(c) - une seconde tendance répondant aux techniques courantes du béton et du béton armé, techniques qui ne réclament pas de résistances exceptionnelles, mais des ciments d'une souplesse d'emploi et d'une adaptation suffisante pour assurer le bon comportement des ouvrages;

(d) - enfin une troisième tendance nécessitée par les techniques très évoluées, exigeant des résistances mécaniques toujours plus élevées, un durcissement toujours plus rapide; ces techniques sont par exemple, la précontrainte et la préfabrication en atelier.

(i) Ce sont évidemment les deux premières tendances dont les techniques emploient la main-d'oeuvre la plus abondante et la moins qualifiée -que doit satisfaire la cimenterie dans les pays en voie de développement et que satisfaisait pleinement l'ancienne cimenterie.

a Rien n'empêche d'ailleurs les unités envisagées de profiter de certains des progrès réalisés par la cimenterie moderne et le problème est en somme d'étudier des unités de 30 000, et de 50 000 tonnes/an, simples, robustes et bon marché pour faciliter la réunion des capitaux nécessaires et l'allègement du prix de revient.

b Le problème est soluble si, à proximité d'un gisement calcaire convenable, on trouve une source d'énergie électrique à bon marché; le combustible nécessaire à la cuisson est un problème relativement moins important -en ce sens que l'on peut transporter le combustible sur de plus grandes distances que le ciment fabriqué- car on peut obtenir, dans la cuisson au four droit, des bilans thermiques excellents, tant avec le charbon, qu'avec le mazout ou le gaz.

7.-

(a) Le ciment Portland ordinaire, facilement obtenu dans ces conditions, répond, pour une part très importante, aux besoins de la construction courante, mais il est encore fréquemment possible d'augmenter le tonnage disponible en utilisant, par exemple, les ressources locales en matières pouzzolaniques.

(b) Depuis quelques années, les normes françaises, et les projets de l'ISO, assimilent au Portland les ciments à la pouzzolane (ou aux cendre volantes pouzzolaniques de centrales thermiques) c'est-à-dire les Portland additionnés de moins de 20 % de pouzzolanes. En Italie, les ciments pouzzolaniques, renfermant de 30 à 40 % de pouzzolane, sont d'un usage courant, au point qu'environ 80 % des constructions édifiées à Rome, il y a quelques années, l'auraient été avec de tels produits.

(i) Dans le cas des travaux de maçonnerie, et sans entrer dans

les détails, on peut dire qu'un bon ciment à maçonner doit être un produit de grande finesse pour donner une grande plasticité à la pâte fraîche et assurer une bonne rétention de l'eau de gâchage; sa résistance à la compression doit être assez faible pour assurer une bonne adaptation du mortier aux contraintes de retrait,

(ii) Le Portland pur donne des mortiers frais insuffisamment plastiques et des mortiers durcis trop rigides, trop fragiles du fait d'un rapport résistance traction/résistance compression trop faible. Mais on sait qu'on obtient de bons ciments à maçonner en broyant, à finesse suffisante, des mélanges de clinker Portland et de calcaire cru (formule américaine); on peut également utiliser à cet effet les mélanges de clinker Portland et de pouzzolane. Le principal défaut de ces mélanges est leur mauvaise résistance au gel; il est certain que ce défaut ne présente aucun inconvénient dans les pays tropicaux. Un autre défaut est la lenteur de durcissement dans les essais normalisés effectués à 20°C; mais là encore les ciments additionnés de pouzzolanes sont favorisés, par rapport au Portland, par les conditions climatiques tropicales.

a L'expérience industrielle de Douala, au Cameroun, a montré, il y a quelques années, qu'une station de broyage, utilisant un mélange de 70 % de clinker importé, puis de clinker de four droit local, et de 30 % de pouzzolanes situées à 80 km environ de l'usine, pouvait mettre sur le marché un produit donnant satisfaction, dans les conditions climatiques régionales, même si les essais de réception, normalisés à 20°C, étaient quelquefois jugés légèrement insuffisants.

(i) Il est indiqué (1) qu'au début de 1961 a été instituée la Compagnie Malgache des Ciments de Morananga qui doit exploiter des brevets malgaches (les premiers délivrés à Madagascar) concernant l'utilisation des matières premières du pays et notamment de pouzzolanes de qualité exceptionnelle.

9.-

(a) De telles matières n'exigent qu'un broyage -et c'est là l'intérêt d'une source voisine d'énergie électrique à bon marché- et réduisent d'autant les frais d'investissement. Il est alors permis d'espérer pouvoir réunir les sommes nécessaires à l'implantation d'une cimenterie modeste.

(b) Encore faut-il pouvoir compter sur différents concours : administrations locales et tiers installés sur place, banques et sociétés commerciales, aide des pays industrialisés pour les études d'un bureau d'engineering.

(c) Enfin, l'administration française a établi une législation favorable pour inciter des capitaux métropolitains à s'investir Outre-Mer, dans la zone franc : primes d'équipement, prêts à long

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(1) Une industrie qui tend à se développer en Afrique et à Madagascar : Le ciment. Industries et Travaux d'Outre-Mer. N° 100, 247,(Mars 1962).

terme à bas taux d'intérêt, facilités financières à moyen terme et garantie accordées aux emprunts destinés à financer les investissements dans les Etats liés à la France par un accord d'association.

10.- CONCLUSION

(a) L'implantation d'une cimenterie dans un pays en voie de développement ne peut être envisagée qu'en tenant compte de nombreux facteurs géologiques, géographiques, financiers, économiques et techniques. Une fois résolus les problèmes de matières premières et d'énergie, c'est la consommation potentielle qui conditionne la technique.

(b) Ce n'est que si l'on est assuré d'une consommation potentielle régionale supérieure à 80 - 100 000 tonnes/an que l'on peut envisager l'implantation d'une unité moderne. Pour une consommation potentielle comprise entre 30 et 80 000 t/an, il est plus avantageux et efficace d'envisager une cimenterie modeste mettant en oeuvre les techniques plus rudimentaires, mais améliorées de la cimenterie ancienne. Enfin des consommations potentielles inférieures ne peuvent être satisfaites que par l'importation ou, éventuellement, par une station de broyage de clinker importé.

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DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

R E C T I F I C A T I F

Prière de noter les modifications ci-après, indiquées par le Gouvernement contributeur :

Page 2, paragraphe 2 (a) (iii), cinquième ligne, lire :

"Kouilou" (au lieu de "KOVILOU").

Page 4, paragraphe 5 (a) (ii), première ligne, lire :

"Mali" (au lieu de "Soudan").

paragraphe 5 (a) (ii) b (i), à partir de la dixième ligne, lire :

"d'une abondante main-d'oeuvre, dont la formation technique est souvent faible il est vrai."

Biffer les cinq dernières lignes.

paragraphe 6 (a), lire :

" (a) Il convient donc, à notre avis, pour apporter à ces pays l'aide la plus efficace, d'adapter aux conditions locales les techniques les plus simples qui ont déjà fait depuis longtemps leurs preuves et qui favorisent la formation technique d'une main-d'oeuvre plus nombreuse. Cette éducation est . . ."

La suite du paragraphe sans changement.

Page 6, paragraphe 7 (b) (ii) a, lire :

" a L'expérience industrielle de Douala, au Cameroun, a montré, il y a quelques années, qu'une station de broyage, utilisant un mélange de 50% de ciment broyé, en sac, 20% de laitier de haut fourneau importés en vrac des usines de l'Est de la France, et de 30% de pouzzolanes . . . . ."

La suite du paragraphe sans changement.

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UNITED NATIONS CONFERENCE
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FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item : D.13

France

THE PROBLEM OF THE CEMENT FACTORY IN THE CONSTRUCTION NEEDS OF THE DEVELOPMENT COUNTRIES

By Henri LAFUMA,
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Paris

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

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THE PROBLEM OF THE CEMENT FACTORY IN THE CONSTRUCTION NEEDS OF THE DEVELOPMENT COUNTRIES

By
HENRI LAFUMA, DIRECTOR, CENTRE D'ETUDES ET DE RECHERCHES DE L'INDUSTRIE DES LIANTS HYDRAULIQUES (RESEARCH CENTRE FOR HYDRAULIC BINDERS) PARIS

(a) The cement factory in industrial countries evolves towards large units which, first of all, give savings in manpower and energy. This framework of maximum productivity is not appropriate to the cement works in developing countries where labour is abundant, if less skilled.

(b) The design of a cement works can only be envisaged if all the geological, geographical, financial, economic, and technical factors are taken into account. Once the problems of raw materials and energy are solved, it is the potential consumption which determines the technique.

(c) Limiting himself to the developing countries of French-speaking central Africa, the author shows that the necessary limestone deposits are non-existent in some countries (Ivory Coast), inadequate (Dahomey), or of poor quality because of excess of magnesium (Sudan, Upper Volta) and sometimes badly sited geographically for the consumer (Cameroons).

(d) If appropriate limestones and energy supplies are available on the spot, it is the potential consumption which determines the technique. A modern unit cannot be considered for any potential consumption smaller than 80,000 to 100,000 metric tons per annum. The example of the cement factory at Rufisque is characteristic, with an output of 200,000 metric tons per annum - enough to satisfy the potential consumption of Senegal.

(e) For a potential consumption between 30,000 and 80,000 metric tons per annum, a modern unit does not appear satisfactory. It should be more efficient and appropriate to install a small cement works using the old, but improved cement-making techniques. This solution has technical and social advantages in that it trains more men. It is also cheaper and enables local pozzolanas to be used.

(f) Finally, even smaller potential consumptions than 30,000 metric tons per annum can only be met by imports or possibly by a crushing station for imported clinker.

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Point de l'ordre du jour : D.7.1 France

DEFINITION DES PROBLEMES SPECIFIQUES POSES PAR LA CREATION DE SIDERURGIES DANS LES PAYS EN COURS DE DEVELOPPEMENT

Par Marc ALLARD,
Directeur général de l'Institut de Recherches
de la Sidérurgie Française

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

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D.7.1. **DEFINITION DES PROBLEMES SPECIFIQUES POSES PAR LA CREATION DE SIDERURGIES DANS LES PAYS EN COURS DE DEVELOPPEMENT**

Communication de M. Marc ALLARD
Directeur-Général de l'Institut de Recherches de la Sidérurgie Française

Préambule - Le terme "pays en cours de développement" couvre un ensemble de situations très variées se trouvant à des niveaux techniques très différents. En Amérique Latine, par exemple, des développements industriels existent et aussi un enseignement supérieur valable. L'aide technique, à un niveau relativement élevé, consiste à fournir les renseignements les plus récents, à discuter des choix de solutions à opérer et ensuite à fournir l'engineering et les équipements non disponibles localement. Les informations économiques nécessaires peuvent déjà être rassemblées par les instances locales intéressées. Les interlocuteurs sont variés : instances gouvernementales ou industriels privés.

Ailleurs, le niveau technique et industriel peut être plus bas, les interiocuteurs se situent presqu'uniquement au niveau des Gouvernements et tout est à faire, des premières études jusqu'aux mises en route industrielles.

Ces derniers cas envisagés ici de préférence exigent des conseilleurs des compétentes multiples et l'existence chez eux d'organisations bien spécialisées.

Les problèmes sidérurgiques naissent dans ces pays pour deux motifs :

I - Besoins de disposer d'une production modeste de fers pour des débouchés locaux afin de réduire les sorties de devises qu'exigent les importations de fer, d'assurer une autarcie, donc une sécurité minimale en cas de difficultés politiques ou économiques, de faciliter le développement d'industries transformatrices, de poser et résoudre obligatoirement les problèmes de transport, de former une main d'oeuvre qualifiée, d'aider à la reconnaissance de toutes les ressources indigènes.

Les prix de revient escomptés ne doivent pas être trop élevés, mais il importe surtout qu'on fasse appel à des matériaux indigènes en évitant d'importer une proportion élevée d'éléments nécessaires aux fabrications. Les prix de revient pourront être d'autant plus élevés que l'autarcie sera plus complète.

II - Désirs de valoriser des gisements de fer existants en construisant des sidérurgies principalement vouées à l'exportation . Dans ce cas, les ressources naturelles doivent être abondantes et bon marché et la réalisation d'usines alors déjà importantes implique :

- leur installation en un lieu d'où les communications soient aisées et bon marché, tant avec les sources de matériaux qu'avec les consommateurs, par exemple côte maritime ou fleuve;
- que les prix de revient soient compétitifs, donc que les matières premières et la main d'oeuvre soient disponibles sur place et peu coûteuses,
- enfin que l'absence actuelle d'industries annexes ne constitue pas un handicap trop lourd pour l'étude de l'usine.

Dans le cas II il s'agira par définition d'usines basées sur la transformation de minerais locaux, donc "intégrées".

Dans le cas I on peut envisager des usines non intégrées, mais il est généralement peu économique d'importer des demi-produits lourdement grevés de frais de transport Ainsi, la construction d'usines non intégrées (laminoirs et forges alimentés en métal de l'extérieur) ne constitue-t-elle le plus souvent qu'une étape provisoire à compléter ultérieurement par des productions de métal sur place.

On peut classer en semi-intégrées les usines produisant leur métal à partir de ferrailles du commerce dans des fours à acier Martin ou électriques. Cette solution présuppose la possibilité d'un approvisionnement régulier en ferrailles, ce qui est assez rare dans des pays non industrialisés, sauf toutefois si l'on se trouve sur une côte maritime bien placée sur le marché international des ferrailles. De telles usines sont toutefois assez vulnérables.

En résumé, les usines non intégrées seront tout à fait exceptionnelles et les usines semi-intégrées ne correspondront qu'à des cas particuliers. Nous nous attacherons donc surtout au cas des usines intégrées appropriées à leur objet.

Les méthodes d'approche et de résolution des problèmes posés à l'Assistance Technique se présentecomme suit :

A. Etudes fondamentales préliminaires

- a) Des pré-études économiques doivent renseigner sur la nature et l'importance :
  - d'une part, des matières premières disponibles (minerai et matériaux annexes). On examinera très particulièrement les possibilités de fourniture locale ou importée d'énergie de toute nature (charbon et succédanés tels que charbon de bois, hydrocarbures liquides ou gazeux, électricité) et on évaluera leur coût comparé. Matériaux réfractaires (argiles, dolomie, etc..) et calcaires sont aussi importants.
  - d'autre part, du marché des produits sidérurgiques, c'est-à-dire des besoins immédiats et futurs du pays et des possibilités d'exportation.

Cette partie délicate du travail est à la base de tout ce qui suit et puisqu'en fait presque rien n'existe encore, on supputera, par comparaison avec d'autres pays les chances de développement des industries consommatrices. On sera conduit à examiner des schémas de petits ensembles industriels dont l'usine sidérurgique n'est qu'un noyau provisoire.

-b) Détermination de la capacité de l'usine et de la nature des produits à y fabriquer.

Aucune étude ultérieure des formules techniques auxquelles on s'arrêtera ne peut être entreprise avant que ne soient définies les quantités et la nature des produits à fabriquer. Or, ces définitions peuvent être totalement différentes suivant les cas :

- Parfois, une simple petite production d'aciers courants (fers à béton, cornières, etc) à l'échelle semi-artisanale mettant en moyenne à la disposition de chaque habitant seulement quelques 4 à 5 Kg annuels de fers (soit 4 000 à 5 000 tonnes par million d'habitants) peut permettre un progrès sensible qu'accentuera encore la présence de quelques moyens de forgeage artisanal, la fabrication d'outillages destinés en particulier à la culture. Il est cependant difficile de descendre au-dessous de 40 à 50 tonnes par jour de production d'acier.
- A l'opposé se situe l'Usine (de 500 000 à 2 millions de tonnes) destinée :

. soit à constituer pour un ensemble de pays assez peuplés un centre d'approvisionnement travaillant dans de bonnes conditions de prix de revient moyen des fers rendus chez les divers consommateurs;

. soit à valoriser un minerai pauvre incapable d'affronter les marchés mondiaux saturés de minerais riches, en procédant en fait à son enrichissement par transformation complete en métal à exporter.

Dans ce cas l'étude des marchés revêt une importance capitale, car si les variations du marché mondial des minerais ne donnent de coups d'accordéon qu'à la rentabilité des investissement miniers, il est plus grave de faire en sus peser les incertitudes de conjoncture sur des équipements sidérurgiques très coûteux.

Dans les deux cas précités, il s'agira obligatoirement d'Usines intégrées qui devront fabriquer peut-être des demi-produits à transformer, mais aussi toute la gamme de produits nécessaire pour répondre aux demandes des marchés.

Notons enfin que ces réalisations se feront le plus souvent par étapes, la première étant de dimension déjà raisonnable et économiquement viable.

-c) Solutions techniques à retenir - Généralités -

Le choix du processus sidérurgique, tout en tenant compte des données techniques les plus récentes évitera les solutions non encore suffisamment éprouvées. Il sera même bon, chaque fois que faire se peut, d'effectuer dans les usines et ateliers pilotes des pays conseilleurs des essais d'application des méthodes envisagées, opérant sur les matières premières à mettre en oeuvre.

On ne peut d'ailleurs pas dire qu'il existe des solutions spécifiques des régions en cours de développement. Il y a seulement pour chaque cas d'espèce une ou des solutions mieux appropriées que les autres.

Il se peut d'ailleurs que des équipements très mécanisés et automatisés s'imposent malgré la formation longue et difficile des spécialistes de grande classe qu'ils requièrent De tels équipements peuvent permettre par contre d'économiser un bien plus grand nombre de techniciens de routine,de formation également longue. Il faut dans ces pays mettre des espoirs d'emploi de main d'oeuvre bien plus dans les industries qui graviteront autour de l'usine sidérurgique que dans cette dernière elle-même.

- Inventaire des solutions à envisager -

Une revue complète de ces solutions est impensable. Aussi bien les experts doivent-ils être instruits des plus récentes techniques et surtout de leurs limites. Nous rappellerons seulement que :

- En sidérurgie extractive (du minerai au lingot) le haut-fourneau perfectionné (lit de fusion préparé, injections diverses, vent très chaud et suroxygéné) regagne du terrain sur le Bas-Fourneau électrique et ne consomme pas plus de coke que lui. Il est très souple, s'adapte à tous les niveaux de production et s'accomode, en remplacement partiel ou total de coke, de l'emploi de combustibles très divers (hydrocarbures, houille, charbon de bois)

. Le Bas-Fourneau électrique cependant progresse grâce à la pré-réduction (ELKEM, Strategic Udy). Son emploi dépend du coût relatif de l'électricité et du coke. Pour affiner la fonte issue de ces appareils on n'envisage pratiquement plus maintenant, sauf cas particuliers, que l'aciérie à l'oxygène pur, de préférence aux aciéries Martin ou électriques.

. Les fours rotatifs, tels que ceux du type RN utilisent encore un réducteur carboné et le produit réduit, séparé magnétiquement, doit être fondu dans un four électrique à acier. Les investissements sont élevés.

. Les procédés de réduction à basse température par les gaz, tels par exemple que :
- en fluidisation : l'H-Iron et le Novalfer; - en cuve : les procédés Wiberg et Hyl comportent des sujétions sérieuses. Ils exigent des minerais très riches et de granulations bien définies. Les produits réduits doivent être transformés en acier dans des fours électriques.

. D'autres procédés sont à l'étude n'utilisant qu'hydrocarbures et électricité, mais ils n'existent pas encore à l'échelle industrielle.

On doit donc bien se garder d'un enthousiasme excessif quand on sort des solutions classiques et on doit étayer d'essais sur des installations existantes les conclusions techniques et économiques avancées.

. La coulée continue simplifiera les installations de laminage subséquentes, surtout dans les usines de dimensions modestes. Elle peut avoir beaucoup d'avantages au regard de quelques sujétions telle qu'une technologie délicate.
- En sidérurgie de transformation (c'est-à-dire de façonnage des lingots en produits marchands) on pourra dans certains cas envisager des nouveautés tels que les laminoirs planétaires à chaud et les procédés d'extrusion, mais certainement dans une mesure limitée.

En résumé, on ne pourra pas plus faire surgir de solutions miracles pour les pays en cours de développement que pour les pays développés, On aura seulement à étudier chaque cas d'espèce.

B. Réalisation

a) L'avant-projet ayant ainsi déterminé les données principales doit passer ensuite aux mains de l'engineering, lequel, en sus de l'équipement sidérurgique à proprement parler, aura à connaître de tous les problèmes annexes tels que génie civil, circuit des eaux, manutentions, etc. Il sera désirable que cet engineering, tout en consultant au besoin les fournisseurs d'équipements, n'ait pas partie liée avec eux. Cependant, après l'établissement des plans, il présentera des projets et listes des consultations à opérer auprès des fournisseurs sélectionnés.

b) La construction et le montage sur place des équipements, précédé des travaux d'entreprise générale interviennent alors, suivis de la mise en route de l'Usine, à assurer par des équipes spécialisées.

C. Aide de formation technique

-a) Les élites dirigeantes des pays conseillés seront documentées et mises en présence d'une motivation détaillée de chaque conclusion partielle, aux fins de compréhension des options prises. - b) Les futurs cadres techniques devront être instruits et entraînés dans les pays conseilleurs, d'une part dans des Ecoles Techniques, d'autre part, dans des Usines utilisant des équipements semblables à ceux qui sont projetés. Tant que des Ecoles Techniques d'un niveau suffisant ne sont pas localement créées il faudra poursuivre cette formation. - c) Le personnel de maîtrise et les spécialistes de fabrication et d'entretien mécanique et électrique doivent certainement suivre à l'étranger la même formation que les précédents, mais il faut s'ingénier à créer rapidement sur place un enseignement professionnel valable, ce qui implique l'envoi de professeurs au moins pendant un assez long temps. - d) Le personnel ouvrier pourra en partie faire son apprentissage sur place, mais l'expérience montre qu'on gagne toujours à le faire participer à l'étranger au fonctionnement d'installations existantes.

Moyens à mettre en jeu - Exemple français

Les Etudes fondamentales préliminaires précitées exigent chez les experts désignés, d'une part une objectivité totale, d'autre part des connaissances techniques et économiques générales assez étendues. Ils doivent être polyvalents et leur formation doit être constamment à jour, ce qui ne peut pratiquement être obtenu qu'au sein d'organismes ad hoc. C'est ainsi qu'en France, la conjugaison des connaissances du BRGM (x) (recherches sur les minerais) et de l'IRSID (xx) (procédés sidérurgiques) associé au CERCHAR (xxx)(coke et charbon) constitue un ensemble parfaitement adapté à cet objet. Les organisations de ce genre détachées de toute préoccupation commerciale sont parfaitement habilitées à porter des jugements en toute objectivité et pour cela leur aide est souvent réclamée. D'ailleurs, leur est assuré en France le concours de diverses Sociétés françaises d'études, telles que SOFREMINE pour les questions minières, SOFRELEC pour les questions électriques et en ce qui concerne particulièrement la sidérurgie : SOFRESID et les autres bureaux d'études sidérurgiques.

(x) Bureau de Recherches Géologiques et Minières - (xx) Institut de Recherches de la Sidérurgie Française - (xxx) Centre d'Etudes et de Recherches des Charbonnages de France -

Pour la concrétisation des avants-projets établis, il est nécessaire de recourir aux services d'un bureau d'Engineering, rôle dévolu en France à SOFRESID et autres bureaux d'études sidérurgiques (SEES - CAFL - CETIG, etc.) La construction et le montage de l'usine sont ensuite le fait des constructeurs adjudicataires des travaux qui peuvent puiser dans l'industrie sidérurgique les techniciens nécessaire à la mise en route.

L'aide de formation technique a recours à tout un ensemble de mesures variées. Tout d'abord les élites dirigeantes des pays conseillés doivent être conviées à des voyages d'information qui, en France, sont généralement organisés conjointement par l'Administration et l'Industrie privée dans le cadre de l'ASTEF (x). L'ASMIC (xx) s'occupe en outre de l'envoi de missions d'experts et de la création à l'étranger de centres professionnels et d'information technique.

Pour la formation des futurs cadres techniques, de la maîtrise et des spécialistes dans les Ecoles, Universités ou Usines, la coordination des efforts est en France assurée par les services de la Coopération Technique du Ministère de l'Industrie, dispensateur de bourses; aussi dans une certaine mesure par l'ASTEF et l'ASMIC.

La Sidérurgie française, dans ses Usines, plus encore dans son Institut de Recherches (IRSID)(laboratoires de St-Germain-en-Laye - Usine-pilote de Maizières) reçoit aussi de nombreux stagiaires. De plus, le CESSID (xxx) est également ouvert aux ingénieurs étrangers qui pendant un an y bénéficient de son enseignement très complet.

En ce qui concerne la formation plus massive du personnel ouvrier, elle doit surtout faire l'objet d'explications souvent audio-visuelles dispensées dans le pays aidé par le truchement de cadres envoyés par les pays conseilleurs.

D'ailleurs dans tout ce domaine un effort important et continu est à déployer impliquant par les pays conseilleurs l'envoi régulier de professeurs et conférenciers toujours très désirés surtout s'ils savent psychologiquement bien adapter leur langage et leurs actes à leur auditoire. C'est ainsi que la Sidérurgie française est présente dans plusieurs pays, notamment en Amérique Latine, où principalement sous l'égide de l'IRSID elle envoie souvent de nombreux professeurs ou conférenciers spécialistes.

D'ailleurs les liaisons constantes existant en France entre les Sociétés Sidérurgiques et l'IRSID, les Sociétés d'Engineering et les Constructeurs permettent à notre pays de se présenter avec tous les atouts en mains pour toute assistance technique désirable dans le domaine de la sidérurgie.

(x) Association pour l'Organisation de Stages dans l'Industrie française
(xx) Association pour l'Organisation de Missions Industrielles de Coopération Technique
(xxx) Centre d'Etudes Supérieures de la Sidérurgie française, à METZ.

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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.7.1

France

PROBLEMS RAISED BY THE CREATION OF STEEL INDUSTRIES IN DEVELOPING COUNTRIES

By Marc ALLARD,
Director General
of the French Iron and Steel
Research Institute

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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PROBLEMS RAISED BY THE CREATION OF STEEL INDUSTRIES IN DEVELOPING COUNTRIES

By
MARC ALLARD. DIRECTOR GENERAL OF THE
FRENCH IRON AND STEEL RESEARCH INSTITUTE

Technical aid requirements vary from country to country. Some already have industries and training centres, in which case assistance will be sought by both government departments and private industry. In others, where the technical level is lower, requests for aid will virtually be confined to government level and the range of subjects covered will be much greater. It is the latter case with which we shall mainly deal in this paper.

The creation of local steel industries has two main objectives:

1. To manufacture steel products for local markets in order to guarantee the country concerned a certain amount of independence, to limit the drain on its currency and to stimulate the creation of other industries. Not only must manufacturing costs be kept low, but the maximum amount of local materials and labour must be used in order to eliminate dependence on imports.

2. Alternatively, to exploit and develop local ore-fields, possibly too poor to compete on the world market. The location of the plant depends on transport facilities for raw materials to the plant and for finished products from the plant to consumers. Coastal or river sites are most suitable. Manufacturing costs must be competitive and imports of materials kept to a minimum.

The most suitable type of plant will be the integrated one. This avoids the import of semi-manufactured products required by non-integrated plants, which will constitute no more than a temporary phase. Semi-integrated plants using local scrap may also be set up, but only in special cases.

Ways of providing technical aid.

A. Preliminary basic studies will include: a) Exploratory economic surveys relating to raw materials, energy sources and markets for steel products; b) A study of the capacity of the plant and the range of products to be manufactured. Capacity may vary from 12,000 to 2,000,000 tons per annum according to circumstances. Small plants may be useful in some countries and large plants may be very vulnerable to disturbances in world markets; c) A study of the technical aspects of the plant. All cases in developing countries are special ones and there is no specific solution suitable for these countries as such. Mechanisation and automation will help to reduce the need for training too many technicians for routine duties.

No list can be given of all the possible solutions. This will be a matter for decision by specialists on the basis of data supplied to them. In steelmaking (from the ore to the ingot), we know that the blast furnace and direct reduction electric furnace (if electricity is cheap) have made great strides and are still the most popular methods. The blast furnace is a very flexible plant. Other processes of the indirect reduction type should only be recommended after considerable thought, since they need very rich, well-dressed ore and entail the remelting of the reduced product. A blast furnace working on hydrocarbons or charcoal represents a

serious competitor to these indirect reduction methods. The adoption of continuous casting is an advantage in that it cuts the cost of rolling mill plant. In steel shaping (from the ingot to the finished product), new methods such as planetary hot rolling mills and extrusion processes should be considered.

B. As regards the construction of the steel mill and the assembly and starting-up of the plant, reliable and independent engineering consultants will be consulted and suppliers of equipment approached after detailed discussions.

C. Aid in the form of technical training must be extended to a wide range of levels: a) management personnel, advised directly by specialists and invited for study tours and practical courses; b) future senior technical staff, to be trained and educated in the advising countries and then in technical colleges to be set up in their own countries; c) supervisory and specialised personnel for whom the foregoing procedure will be used, but to a lesser degree; d) routine staff, some of whom will also have to be trained abroad.

Channels through which aid is available - the French example.

The preliminary basic studies (see Section A) will require polyvalent specialists whose knowledge is continually kept up to date, such as those to be found in France at the Bureau of Geological and Mining Research (BRGM) for ore problems, at the French Iron and Steel Research Institute (IRSID) for questions concerning steel manufacture and at the French Coal Study and Research Centre (CERCHAR) on coke and coal. These are pure research bodies without any commercial preoccupations.

In case of need they can be supplemented by various French firms of engineering and planning consultants such as SOFREMINES for mining, SOFRELEC for electricity and steel manufacture and SOFRESID and other firms purely on steel manufacture.

At the detailed planning stage, the firms of consultants listed above will draw up outline projects, and the building and assembly of the plant will be covered by the contractors selected, assisted by experts made available by the steel companies.

Aid in the form of technical training (visits, practical courses, missions, the establishment of training and information centres in developing countries) can take place through a number of channels, which are co-ordinated in France by the Association for the Organisation of Practical Courses in French Industry (ASTEF) and the Association for the Organisation of Industrial Missions of Technical Co-operation (ASMIC), representing both private industry and the government. The latter body also awards study grants. In its own country, labour for steel plants can be trained by audio-visual media. In addition, regular visits by professors and lecturers to developing countries is to be recommended.

The French steel industry, in conjunction with IRSID in particular and also with the Centre for Higher Steel Studies at Metz (CESSID), plus the engineering and planning consultants and steel plant contractors, can provide a comprehensive and effective range of assistance covering all aspects of the steel industry.

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Agenda Item: D.5.1

United Kingdom

THE UTILIZATION OF TROPICAL PRODUCTS FOR PULP PAPER AND BUILDING BOARD PRODUCTION

By A.E. CHITTENDEN,
Tropical Products Institute, DSIR

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The Utilisation of Tropical Products for Pulp Paper and Building Board Production

By

A.E. Chittenden, Tropical Products Institute,

D.S.I.R.

Since this paper will be entirely concerned with the utilisation of material derived from living plants, it can be said that the raw material requirements for pulp, paper and building board manufacture are essentially similar since they all need to possess to a greater or lesser extent a cellulosic fibrous structure. In fact the dividing line between some pulps used to produce very low grade papers (e.g. the mechanical and semi-chemical pulps) and those used to produce boards which require a pulping process is not very easily drawn. Here it is very largely a question of quality (and cheapness) and very briefly the higher the quality of the product the more exacting is the pulping process and the specification of the raw material. In general the considerations which concern raw materials for pulp would also apply to those for these types of board (i.e. boards which have been given the designation "fibreboard" and which are marketed under a large variety of trade names)

The exception is those building boards which are produced by binding un-pulped cellulosic material together with either a synthetic resin (particle board or chipboard) or with an inorganic binder such as cement or plaster (e.g. plaster board, wood-wool slabs). Here no pulping process is involved but is replaced by a rather specialised (for timber at any rate) flaking or chipping process to make the particles of suitable dimensions. As will be seen with paper and board, timber is at present the most widely used and preferred material and many commercial plants in Europe and the U.S.A., are possibly just as exacting in their timber requirements as are the pulp makers. There is a rather greater scope here with agricultural and non-timber materials but it must be remembered that a particle (or chip) specially engineered for the purpose will always make a better quality board than will a natural "particle" (e.g. a waste nut shell) which was designed for an entirely different purpose. A great deal more research is needed on various aspects of particle board manufacture from both timber and non-timber materials. Some such work is at present in progress at the Tropical Products Institute, that on groundnut shells has already been published, and reports on other tropical agricultural residues and timbers will follow.

3. Two surveys of the experimental pulp and paper making activities of the predecessors of the Tropical Products Institute (i.e. The Imperial – now Commonwealth – Institute and the Colonial Products Advisory Bureau-Plant and Animal) have been published, one by Furlong and Hill (1) and the other by Coomber (2). Between them these two papers describe the large amount of work carried out at this Institute alone on the pulping properties of a very large number of species (almost all naturally occurring rather than of agricultural waste or forest plantation origin). It is also

(1) Furlong J.R. and Hill E.L., Paper Making Materials of the British Empire, Bull. Imp. Inst. 42 (1944).

(2) Coomber H.E. Pulping Studies with Colonial Tropical Hardwoods as Paper Making Materials F.A.O. Forestry and Forest Products Studies. No.3, 51-62 (1952).

immediately obvious from these papers that the bulk of the experimental work on the evaluation of tropical raw material at the Institute since its foundation at the end of the last century has been devoted to timber. This trend is also to be found in the post-war reports of the T.P.I. and of other research laboratories of continental countries (e.g. the old Regie Industrielle de la Cellulose Colonial en France, the Royal Tropical Institute in Holland, the laboratories of the Ministry of Colonies in Belgium and the Forest and Forest Products Research Laboratory in Germany to mention only a few) who have been engaged on similar work. A study of the publications and conference report of F.A.O. concerned with this subject also confirms this trend. This is not to indicate that non-timber raw materials are unimportant as potential pulp and paper making materials in the tropics but rather to accentuate the fact that in practice the number of these non-timber materials which are utilisable is quite small. In fact the present commercial exploitation of these materials in the tropics is virtually limited to three, two of them being agricultural residues (bagasse and rice straw) and the other being bamboo. Because the consideration of these non-timber materials is so closely associated with other industries and because there is already such a large measure of published commercial and technical information on them it is not proposed to deal with them further in the paper.

4. Returning to the utilisation of tropical timber for pulp, paper and board a further analysis of the literature referred to in general terms above reveals that, within the reported material on timber, there is a definite pattern in this research work. For a period immediately before and after the second world war there was considerable pulping research activity on materials which have together become known as "mixed tropical hardwoods", which are obtained from naturally occurring tropical high forest. The most marked feature of this tropical high forest from which this material originates is the enormous number of species present: for example, in Malaya out of some 3,000 wood species, nearly 600 reach timber size and any one acre of natural forest may contain trees of up to 100 different species. Comparable figures apply to tropical forests in other parts of the world.

5. Out of this enormous number only a handful can find a market today; in a number of tropical territories, (for example, Trinidad, Malaya and Uganda) local consumption is reaching a point where an increasing number of species, if of reasonable form, can be marketed locally for timber. This is assisted by the increasing use of preservative treatment. On the other hand in territories such as British Guiana, British Honduras, West Africa, Borneo and Sarawak current exploitation is based on selective export markets. It is, of course, understood that a much higher price can be obtained for timber for use as such than for use as pulpwood.

6. For many years to come only a small but gradually increasing proportion of the natural stand is likely to be utilised for timber. To what extent can the residuals be used for production of pulp or reconstituted building board? It is now generally accepted that there is little technical difficulty in pulping heterogeneous mixtures of tropical hardwoods, at least by the sulphate process. This has been ascertained by many research workers and also on a small commercial scale at the Bimbresso project on the French Ivory Coast. However, very extensive experimental programmes using these mixed timbers have been carried out in the Philippines and by Belgian and Dutch workers. A very large mass of factual data has been built up on material of this type from all over the tropics, the work of Peel (3) on Malayan timbers, Istas (4) on Congo timber, Peteri (5) on West African timbers, of a number of South American workers at

(3) Peel J.D. Pulp and Paper Manufacture in Malaya Parts I-V Malayan Forester, 22, 62-89, 23, 255-286 (1959-1960) and 20, 187-196 (1959).

(4) Istas J.R. et al Etude de quelques bois congolais Publications de l'Institut National pour l'Etude Agronomique du Congo Belge, Serie Technique No.59 (1959)

(5) Peteri R. Pulping Studies with African Tropical Woods F.A.O. Forestry and Forest Products Studies No.3, 43-50 (1952).

the Latin American Meeting of Experts on the Pulp and Paper Industry in 1944 (6) and of the present author (7) which represents only a very small selection of that which has been published. Commercial exploitation has not followed and as far as is known, there is now no commercial mill in the world (the Ivory Coast project has now closed down) which uses a large number of species (i.e. more than about ten) as its normal raw material. The reasons for this are not difficult to find, the varying densities and chemical composition of these timbers, for example, impose restrictions on the choice of pulp production processes. For instance, the presence of an appreciable proportion of high density or highly resinous timber would make some semi-chemical processes difficult. This restriction of choice of process may pose further problems in underdeveloped countries owing to the limited range of naturally-occurring chemicals. These are almost essential because they play an important part in the economics of pulping. Further, the quality of this mixed hardwood pulp is such that it is doubtful whether it could be freely sold on the world's pulp market in competition with that produced from the large managed coniferous forests of N. America, Scandinavia and elsewhere. Many of the countries which are faced with this problem have at present only a small "all grades" pulp and paper consumption and are unlikely, for many years, to be able to utilise more than a small amount of this locally mixed material.

7. The extraction from the natural stands of large timber of this type for pulp wood is likely to be expensive; many of the species are non-floaters, so cheap water transport is impossible. Much of the timber is over-mature and often contains a large proportion of fungally attacked timber, which is not discovered until it is chipped, while there is a tendency in tropical conditions for the timber to deteriorate rapidly on the forest floor or in the log-yard.

8. All these factors tend to make the cost of pulp wood from this source expensive, while the cost of pre-pulping treatment of this material would also tend to be high. In general therefore one may conjecture that the probability of economic pulping of these mixed residuals is not high and that better prospects are afforded by the products of managed tropical forests. This is rather borne out by the fact that, during the last five years or so research efforts on tropical timber utilisation for pulp have swung away from work on mixed species towards what can be described as "selection". This work can be classified into that which has been on a close study of individual species of the tropical high forest and that which has been devoted to a study of species (both deciduous and coniferous) which are potentially useable for growing in pulpwood plantations. In fact, there is a lot to be said for the rather over-simplified statement that as soon as selection (for pulpwood that is) is envisaged it would almost certainly be advisable to manage the natural forest completely or, better still, cultivate the more desirable pulp producing species in a plantation.

9. The various aspects of these subjects have already been adequately discussed and summed up by Peel (3) by Coursey and Chittenden (8) and by the present author (7). The general conclusion is that, as far as the tropics are concerned the existence of large areas of unmanaged tropical high forest (and very often of other naturally occurring vegetation) does not necessarily mean that there also exists a readily available source of material for pulp, paper and board. In the great majority of cases the raw material source for such industries will have to be derived (with the exceptions mentioned above)

(6) Report of the Latin American Meeting of Experts on the Pulp and Paper Industry F.A.O. E.T.A.P. No.462 (1954).

(7) Swabey C. and Chittenden A.E. Potentialities of Tropical Forest in the World's Timber Economy 5th World Forestry, Congress, Seattle, (1961).

(8) Coursey D.G. and Chittenden A.E. Pulp and Paper Research in Nigeria, World Paper Trade Review, 157, 203-208 (1962).

from plantation timber or from managed natural forest. The complete utilisation of managed forests needs outlets for thinnings and so on which are otherwise useless for traditional industrial purposes. Such material, however, would be a near ideal source of good pulp, since it possesses very few of the inherent disadvantages of the heterogeneous natural stands. They have, in fact, arisen from a selection process.

10. It is not possible to discuss the relative technical merits of deciduous and coniferous timbers for pulp, paper and board manufacture but there appears to be no doubt that pulpwood plantations in the tropics can be established in surprisingly short periods of time. It is considered most important, therefore, that at the outset of the investigation of a pulp paper or board making project a forester should take an active part because from historical, technical and economic considerations he will almost certainly have to be relied upon as the producer of the mill's basic raw material. Further, the heterogeneous high forest should be looked upon as a source of lumber rather than of pulpwood and efforts should be made, as soon as a pulp project is envisaged, to get one of the many research Institutes working in this field to recommend (and if necessary investigate) species which can be grown in plantation either specifically for pulpwood or in conjunction with new afforestation schemes, i.e. species which would be available as thinnings.

ACKNOWLEDGEMENTS

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SUMMARY

Agenda Item: D. 5. 1

United Kingdom

THE UTILISATION OF TROPICAL PRODUCTS FOR PULP PAPER AND BUILDING BOARD PRODUCTION

By A. E. CHITTENDEN,
Tropical Products Institute,
D. S. I. R.

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The Utilisation of Tropical Products for Pulp Paper and Building Board Production

By

A.E. Chittenden, Tropical Products Institute,

D.S.I.R.

SUMMARY

The efforts made by the Tropical Products Institute and others engaged on similar work to find suitable pulp, paper and board making materials from naturally occurring tropical vegetation are briefly reviewed. The special needs of the building board industry is also summarised. The conclusion is reached that, in the great majority of cases, timber either from plantation (preferably) or from managed natural forest will form the main source of raw material for these industries. Nevertheless, it is possible that some waste agricultural residues could form a useful raw-material source for particle board manufacture but more research is needed on this subject.

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Agenda Item: D. 5. 4

United Kingdom

NEW SOURCES OF ESSENTIAL OILS IN TROPICAL COUNTRIES

By G. B. PICKERING,
Tropical Products Institute

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NEW SOURCES OF ESSENTIAL OILS IN TROPICAL COUNTRIES

G.B. Pickering

Tropical Products Institute

(a) Uses of Essential Oils and their Value as Cash Crops.

1. The widespread use of perfumes and flavouring materials is characteristic of the civilized way of life and it is readily observed that any rise in the standard of living of a country brings increased interest in their use. Essential oils, either in their isolated form, or as occurring naturally in spices and herbs, are the traditional basis for perfumes and flavours and, although synthetic products from the organic chemical industry are available and take a part of the expanding market, the natural products hold their own by their unique qualities.

2. A section of the Tropical Products Institute specialises in essential oils and spices. The work involves the development of new sources, the assessment of the quality of the products, and research into the composition of new materials.

3. Essential oils are particularly valuable as cash crops for inaccessible areas, since as their name implies, they are the "essence" or distillate of the plants from which they are obtained, and their relatively high price per pound will, in many cases repay air freight or a difficult road haul.

(b) Assessment of the Market Aspects for an Essential Oil.

4. The proposal to develop a new essential oil cash crop by a territory wishing to broaden its economy, must be considered from various aspects. Obviously the potential market for a particular oil is the first consideration and a wide circle of trade contacts with whom the various factors can be discussed is a basic requirement. The Institute is well placed in this respect and in addition, has an Economics and Statistics Division which carries out surveys and collects statistics. A knowledge of the industry, built up over the years, is of great importance in judging the market prospects for an oil since price movements within a short space of time are no indication of the true state of the market and a sudden scare or enthusiasm about the replacement of, or new demand for, a particular oil, needs to be seen in perspective.

(c) Cultivation Trials.

5. Although it is possible to give general information about the cultivation and other requirements of a particular crop, no external body can provide advice comparable in value with that which the local Department of Agriculture can give after planting trials with a new species have been carried out. Not only are these trials necessary to discover if the plant will flourish in its new habitat, they are also vital to find out what effect the new environment has on the quality

of the oil. As an instance of this an attempt may be mentioned to produce Malayan type patchouli oil in the Seychelles. Although the native Seychelles patchouli oil is of very good quality, some buyers prefer the Malayan type and for this reason plants of Pogostemon cablin Benth. were obtained from Singapore and grown by the Department of Agriculture in the Seychelles. When a consignment of leaves from these plants was distilled at the Institute, however, the oil was found to have the properties of Seychelles, and not of Malayan patchouli oil. The effect of the environment evidently predominated over any varietal or other minor botanical difference in the plants.

(d) Evaluating the Quality of the Oil.

6. The testing of oils produced in preliminary trials is, in the first case, the determination of analytical constants to see if they satisfy the requirements laid down in Pharmocopoeias or by Standards Institutions. Such analytical constants, however, give only broad indication of the quality of the oil; more precise information can be obtained by the modern technique of gas chromatography which gives a "picture" of the oil in respect of its volatile constituents and enables a clear comparison to be made with the picture produced under the same conditions by the instrument from a reference sample. Finally, and this is the most important test of all where odour and flavour are concerned, the material is tested organoleptically by people in the trade who handle the particular oil regularly as part of their daily business. If the oil appears promising, but not quite "up to standard" it may often be possible to suggest steps which might be taken to improve it, e.g. loss of the more volatile portion ("top note") might be due to over-rapid distillation of the oil in the initial stages; a pronounced "terpeney" odour could be the result of harvesting insufficiently mature plants when terpene hydrocarbons predominate in the oil but which later, in the mature plants, are partially replaced by esters and alcohols and other oxygenated compounds.

(e) Distillation.

7. The knowledge that an oil of satisfactory quality can be produced and which trade users think will find a market, is the basis from which full production, first on a pilot scale, and then expanding according to circumstances, can commence. There are, however, many difficulties which have to be overcome before any substantial development is achieved.

8. If the crop has been developed by the Agricultural Department, individual growers must be found willing both to grow it and at the same time to master the technique of distillation (not in fact very difficult, but often seeming to be to those only accustomed to normal agricultural processes). The distillation set-up usually consists of a separate steam boiler, the still itself and the condenser, together with the necessary connecting pipes. The plant material is placed in the still, usually on a perforated support to keep it clear of the steam coils, and steam blown through the charge carries the oil vapour with it into the condenser. The mixture of essential oil and water emerging from the condenser separates into two layers. The oil is generally filtered and dried before being placed in its container. It some instaces, where the oil is partly soluble in water, the water layer is returned to the still (a process known as "cohobation"). Here it is evaporated by the closed steam coil in the base of the still to give more steam for the distillation and liberate its dissolved oil. In effect, this process reduces the total volume of water used in the distillation and hence the oil lost by solution. Where a boiler of adequate capacity is already available at a factory, e.g. a sugar refinery, near the growing area, the still may be sited near it. The material used for the still body itself is not important but the condenser must not be made from a metal which can spoil the oil. Generally speaking,

advice should be taken on the design of this unit from technicians well acquainted with the distillation process as applied to essential oils. Some firms engaged in the manufacture of chemical plant appear to have little idea of what is involved. Where essential oil development is being attempted over a wide area, a mobile unit, with boiler and still mounted on a truck and trailer, may be adopted, but this technique is not generally applicable to full scale production. The cost of the distillation unit as an overhead is proportionately lessened if several oil-bearing plants are cultivated which do not have the same harvesting periods so that the unit is in operation more continuously. Sometimes firms in the user countries may be willing to provide the capital for a distillation plant in exchange for a contract to purchase the oil over a period of several years.

(f) Two Considerations of General Importance.

9. Before considering some examples of the development of essential oils there are two general points concerning their production which must be mentioned. These are the importance of maintaining both the quality of the oil and the continuity of supply. Growers of the more usual crops are sometimes lured into producing essential oils by the high prices listed for many of them. High priced oils are difficult to produce for one reason or another, e.g. the plant itself may be difficult to grow, or the yield of oil may be extremely low. An expensive oil is expected to be of the highest quality. Too often a new grower will produce an oil, perhaps from plants harvested at the wrong time, or which has been badly distilled, and will express surprise because either he cannot sell it at all, or else he must dispose of it at a price well below the current market list. With regard to continuity of supply it must be remembered that a new oil is never exactly like one from an established source and a perfume manufacturer may have to revise his formulations or bring out a new composition in order to make use of it. Naturally he must be assured of continuity of supply for a number of years before he will undertake these changes.

(g) Examples of the Development of Essential Oil Production.

10. In conclusion it may be of interest to outline two developments of new sources of essential oils with which the Institute has been concerned.

(i) Geranium Oil in Kenya

11. Geranium oil has been produced spasmodically in Kenya, and to a lesser extent in Tanganyika, since the beginning of this century, but the oils produced in these early years had low ester values and were weak in odour.

12. After the last war, however, one of the Institute's advisers in the trade pointed out that whilst some East African geranium oil was of good quality, it did not resemble the Bourbon type of oil which was in demand and he suggested that the Institute might obtain plants from Reunion for cultivation in Kenya. By arrangements made through official channels, cuttings of geranium were obtained from Reunion in exchange for seeds of the varieties of tea grown in Kenya. Of the original cuttings only two survived, but these were sufficient to establish the strain.

13. The first of the oils distilled from plants raised fromthese cuttings was favourably received by the trade, and since then the Institute has co-operated both with the Agricultural Department and private planters in analysing samples of oils and obtaining trade valuations.

14. Although the production of geranium oil in Kenya, which is centered round Lumbwa, fell during the years 1956-1958, conditions have improved since and the Bourbon strain, introduced in 1955, has been used increasingly

for new plantings. It was reported in East African Trade and Industry, January, 1961, that although Kenya's exports of the oil were then only about 2 tons, they could be increased to at least 10 tons and would then be worth something of the order of £100,000 to the country.

(ii) Nindi Oil

15. In 1930, a farmer in Northern Rhodesia, sent to the Institute a sample of an essential oil, together with a specimen of the flower from which it had been distilled. The plant was found to be a new species of Aeolanthus and the oil, known as nindi oil following the native name of the plant, was found to be a good source of geraniol, comparable with palma rosa oil.

16. A few small batches of the oil were produced, and then in the late 1950's the plant came to the notice of the Development Commissioner from the Northern Province who, realising that such an indigenous plant might provide a useful cash crop for this difficultly accessible area, arranged for trial plantings to be made on the Agricultural Department's lands, whilst the help of the Institute was sought in finding an outlet for the oil.

17. Samples of oil aroused the interest of a leading firm of soap manufacturers and arrangements were made to produce the oil on a pilot-plant scale.

18. Since then a full scale distillation unit has been designed and this is now in operation in Northern Rhodesia. Provided that the quality of the oil is maintained and the price remains steady there should be a satisfactory outlet for this new product in the soap perfumery industry.

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SUMMARY

Agenda Item : D. 5. 4

United Kingdom

NEW SOURCES OF ESSENTIAL OILS IN TROPICAL COUNTRIES

By G. B. PICKERING,
Tropical Products Institute

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SUMMARY

NEW SOURCES OF ESSENTIAL OILS IN TROPICAL COUNTRIES

G.B. Pickering

Tropical Products Institute

An improved standard of living brings a greater use of essential oils in perfumery and food flavouring. Their high price per pound makes them important cash crops for difficulty accessible areas.

Some of the steps necessary to establish a new source are:

(a) assessment of the market position for the oil;
(b) cultivation trials;
(c) evaluating the quality of the oil by scientific means and organoleptically;
(d) procuring a suitable distillation unit to deal with large scale production.

The importance of maintaining a uniformly high quality and steady supply of the oil is emphasised.

Two developments in African essential oils with which the Institute has been concerned viz., Reunion-type geranium oil in Kenya and Nindi oil in Northern Rhodesia, are outlined.

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Agenda Item: D.3.4

Canada

THE USE OF RADIOISOTOPES AND SPECIAL INSTRUMENTATION FOR PROCESS CONTROL AND DEVELOPMENT IN THE MINERAL AND METAL INDUSTRIES

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THE USE OF RADIOISOTOPES AND SPECIAL INSTRUMENTATION FOR PROCESS CONTROL AND DEVELOPMENT IN THE MINERAL AND METAL INDUSTRIES

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INTRODUCTION

1. The present climate of international cooperation and technical aid extended to many of the less-developed areas provides them with an opportunity to benefit from the experience gained and advances made in other countries to obtain the highest possible productive efficiency. The extent to which electronic and radioactive instrumentation can be employed in the mineral and metallurgical industries depends greatly on the level of operations. The opening up of the mineral resources of less-developed areas can be broken down into the usual three phases through which any industrial development must pass: exploration, process development, and routine processing. To these should perhaps be added long-term research as a fourth phase usually associated only with more advanced technologies. Each of these phases has its own specialized requirements for equipment, some of which depend heavily on the available personnel and their relevant skills. It is this interplay of improved process efficiency by semi-automatic controls and its requirements for skilled personnel that will be discussed here as it applies to resources development in underdeveloped areas.

2. In the three development phases mentioned, there is a steady increase in complexity in equipment requirements as one passes from exploration to routine processing. Opposed to this, there is a reverse process of dilution in the average level of skill and specialized knowledge required as the scope of operations grows.

3. The exploration phase usually requires a highly knowledgeable person directing a team capable of using a range of instruments and techniques under constantly varying conditions. These techniques include various methods of aerial surveying, ground prospecting and borehole logging, supported by geochemical and mineralogical analyses. The less-developed areas may well depend on technical aid from more advanced countries to press ahead in this field for many years to come.

4. The process development phase involves small-scale mill tests, beaker-scale laboratory extraction work and, finally, pilot plant operations. All these operations require an experienced staff and well-equipped laboratories. Much of the equipment must be properly instrumented to provide all necessary data on process variables and laboratory results, such as analytical determinations, feed densities, flow rates, pH values, gas pressures and many others. Instruments for such measurements have been available commercially for many years and it should not pose too big a problem to train operators to collect and record instrument readings. The actual direction of development tests must always devolve on a trained professional with considerable theoretical and practical experience, who in many cases may have to devote a fair share of his time to training his operating staff.

5. The routine processing or mill operating phase will in general depend to the greatest extent on local resources. The design of the plant must take into account both economic and labour problems in addition to the usual requirements for a high degree of plant efficiency and reliability. In the mineral and metal industries this often implies that an early decision has to be made whether to adopt more modern, semi-automatic means of process control and operation, or whether to retain a more traditional approach involving a great number of relatively unskilled workers performing routine operations as well as their training and capabilities permit.

6. It has often been argued that in many underdeveloped areas unskilled manpower is the chief readily available resource and that the latter approach is more suitable, particularly since skilled technicians may be scarce and breakdowns of expensive control equipment may be hard to remedy due to lack of spares and of experienced repair men. However plausible such an argument may appear, particularly as a means of ensuring wider employment of unskilled labour, it suffers from a number of obvious contradictions under present-day conditions.

7. One is the inherent waste of valuable resources in mining and metallurgical operations conducted without proper control of process variables. Experience in Canada and in many other countries has shown that spectacular improvements can often be made in the yield and overall production of extraction plants when important chemical or physical factors are properly controlled; this in most cases leads to a substantial lowering of costs of production. Many of these factors cannot be judged by the operator by experience alone, but require instead the use of properly designed, often highly specialized, process instrumentation.

8. The second weakness in the argument for the use of large numbers of unskilled labour is its inherent inefficiency. In those countries where this approach has been practised widely, it has been found that almost invariably the labour force suffered from excessive turnover. This required a large proportion of the work force to be tied up in training courses, lasting from a few days to several weeks in some cases, and an often longer period of adjustment and learning on the job, with a low level of average efficiency and relatively high cost of production per man.

9. This practice contrasts with a semi-automatic plant installation operated by a smaller number of more highly trained men who are less likely to find competitive posts elsewhere at similar remuneration. By careful selection, a sufficient number of men can be chosen to attend training classes similar to those given by several North American instrumentation companies to acquaint technicians thoroughly with the operation and maintenance of selected electronic equipment. Such courses may last two to three weeks and do not demand any theoretical knowledge of the process being controlled or of circuit theory as such. Extension of such schemes to many of the less-developed countries, together with mechanical and electrical design to suit the climatic conditions of the area, would go a long way to ensure efficient and economic operation of plants.

10. It is an obvious corollary that probably more care has to be given than hitherto to engineering design of process instrumentation intended for use in less-developed areas, where often very adverse climatic conditions and uncertain electrical power supply conditions will be encountered. To minimize repair problems, more equipment should

be designed in modular sub-assemblies so that defective sub-units can be readily replaced by spare units of easy accessibility and moderate cost. This is achieved to an increasing extent by means of printed circuit techniques and transistor circuits. Such an approach to servicing is likely to overcome the common tube replacement problem and may be more adaptable to regions with difficult communications.

11. Another vital matter, which can only be mentioned in passing, is the need for detailed instruction manuals with complete circuit and layout diagrams, and careful operating and trouble-shooting instructions in the language of the prospective user. This may well prove to be a major problem to the average instrument supplier and may deserve some special government attention and support.

THE USE OF RADIOACTIVE SOURCES IN CONTROL EQUIPMENT

12. Radioactive materials are used to an increasing extent in the metallurgical industry. Because of their relative novelty and the special legislation covering their use in most countries, many potential users still feel mildly uneasy when the use of radioactive materials is suggested in routine operations. For a sensible discussion it is essential to classify such uses according to whether the radioactive material is enclosed or sealed permanently, or whether it is dissolved or entrained in other substances, and according to its mounting, either in a fixed location or in a mobile installation.

13. Mobile, sealed radioactive sources are used primarily in exploration work and for radiographic inspection. Typical applications include gamma-ray and neutron borehole logging[1, 2], gamma-activation analysis of beryllium[3, 4], and other neutron sources for mine analyses[5]. The need for mobility limits the amount of shielding that can conveniently be carried, although truck installations containing several curies of activity have been used. Needless to say, careful handling in accordance with instructions is required to avoid overexposure of the operator or any other bystanders.

14. Similar considerations apply to the use of fixed, sealed sources in control equipment. While the question of the usefulness and desirability of reactor construction in underdeveloped areas is still a contentious subject, there can be no question as to the usefulness and economic advantage of utilizing radioactive sources in certain industrial applications.

A properly shielded radiation source, installed in flow or density gauges, in itself presents no problem of handling or maintenance; only its associated electronic detector and control circuits will require periodic inspection and maintenance, like any other electronic gear. In general, no great difficulty has been encountered in designing such industrial gauges in such a way that any operator is well shielded from any radiation from the radioactive source, thus avoiding the need for classifying him as an "occupationally exposed person". If the source is limited in use by the half-life of its effective nuclide, replacement for such radioactive sources can be obtained quite readily from any of the many countries now exporting radioisotopes.

15. The main advantages of radioisotope radiation sources lie in their ready availability, relatively low cost, absence of moving parts or high-voltage circuits (which might require frequent maintenance), silent operation, and simplicity of installation. The latter point becomes evident when one compares the installation of a radioactive density gauge or level indicator outside the pipe or vessel containing the medium being controlled with any alternative non-radioactive method. All these advantages matter when maintenance and staff training considerations are paramount. By choosing a radioisotope of the appropriate character as to type of radiation and energy emitted, suitable conditions can be established to meet a wide variety of requirements[6]. Most of the gauging systems in industrial use utilize changes in the intensity of radiation transmitted or backscattered from the medium under observation. This radiation level is detected by means of a Geiger counter, scintillation counter or ionization chamber, integrated, and then fed to a conventional electronic recorder or controller.

16. Industrial uses of sealed sources can be classified as follows:

a) High-level radiation sources for purposes of sterilization, pasteurization and food preservation, as well as a processing technique in the plastics industry[7], and the petroleum industry[8];
b) Static eliminators and similar ionizing devices;
c) Thickness gauges, density gauges and level indicators;
d) Markers and indicators, such as are used for emergency lighting and labels or for the identification of selected materials;
e) Flow meters and radioactively tagged "go-devils" in pipe lines[9].

17. Of these, only the third and last groups qualify as standard process control equipment in the sense that they can be obtained commercially and may be part of an overall program of plant control and process supervision. Among these applications the use of radioactive sources in thickness and density gauges for slurries, solutions, metal foil or paper by transmission or backscattering methods have received the greatest attention[10,11,12], but many other applications are constantly being introduced. Similarly, a wide range of level gauges are in use to control liquid levels in leach tanks and oil refineries[13], scrap metal feed in blast furnaces[14], and coal or coke levels in fuel hoppers.

THE USE OF RADIOACTIVE TRACERS IN METALLURGY

18. The use of radioactive tracers, i.e., essentially unsealed, dispersed radioactive materials, calls for a different philosophy and more careful handling precautions. Tracer methods are most useful in development work and for occasional checks of proper operating conditions in routine process work. Their use in continuous process operations is rarely feasible, both for reasons of cost and the limitation in supply, and because of difficulties in supervision and waste disposal under such conditions.

19. There are many potential uses of tracers in the development of chemical processes, the development of mill circuits in extractive processes, and in pyrometallurgy. Typical uses included measurements of flow-patterns in leach plants[15], of contact and residence times in kilns and furnaces[16], of leak detection in pipe lines[17], and of flow problems in hydrology and mining[18]. Although the technique of applying radioisotopes in such tracer tests is not difficult, they should be conducted by a properly qualified scientist or engineer to guard against unexpected exposures and serious contamination. However, the usefulness of tracer methods in the metallurgical field is so great, and the light they can shed on actual plant operations so useful, that one can only hope that a steadily increasing number of scientists from less-developed countries will be able to receive training in this field.

20. A few examples only can be given here of tracer applications in extractive metallurgy and related fields. By adding a suitable tracer it has been found possible to check flow conditions in leach tanks and flotations cells, and to remedy undesirable short-circuit conditions. Similarly, in kiln operations adsorption of a tracer solution on a feed sample can indicate residence times of different feed components, segregation effects, furnace brick wear, pile up and possible short-circuiting of finer fractions. In mines, radioactive tracers provide a better means than fluorescent tracers to tag mine waters and to investigate leakage or contamination problems.

21. In all these cases, careful analysis of the problem can lead to safe use and ultimate disposal of radioactive materials. However, it is not recommended that unsealed radioactive materials be used in any continuous application where the total quantity used may be excessive and ultimate recovery of the active material impractical or impossible. The "post-activation" of non-active tracers may be a possible answer to these problems.

ELECTRONIC EQUIPMENT AND PLANT CONTROL

22. All these radioactive uses as well as other control applications depend on the development of reliable and relatively simple electronic circuits. By using transistors to the fullest possible extent, maintenance problems and down-time can be greatly reduced and the problem of replacement parts can be minimized.

23. There have been many developments of control equipment for mills and extraction plants in recent years and it may be useful to mention a few here that have been developed in Canada. Equipment is now available to control automatically the load of grinding mills, the conductivity of leach solutions of metalliferous ores, the oxygen content of cyanide solutions in gold extraction, or the iron content of iron ore concentrates. Considerable effort has been devoted to improve process control in the extraction of uranium. Automatic picker units have been devised to remove non-radioactive gangue from mine ore; methods for the rapid assay of ore and automatic control of effluent solutions have also been introduced. Many of the lessons learned in the uranium industry are now being applied to other branches of the mining and metallurgical industries. This is particularly relevant to some of the older industries like coal mining, gold mines, iron mines and steel plants. In all of them there is a gradual awareness of the benefits that can accrue from a detailed knowledge of the plant process and the direct control of plant conditions. Most of the instrumentation involved has been used in the laboratory for many years, but it is only in the more modern plants that routine records are kept continuously of such variables as pH, moisture, density, temperature, porosity, gas content, conductivity or pressure.

24. As the more mechanically-minded among the metallurgists are converted to accepting such electronic instruments as commonplace in the beneficiation and refining of metalliferous ores and other minerals, the level and value of production of such materials is bound to improve.

25. It may well be that those countries where a mineral technology is started without too many entrenched preconceptions may find it easier to proceed to optimum conditions of semi-automatic process control. The less-developed countries are fortunate that much of this control technology is available for their use and can be readily adapted to their needs. By grasping these opportunities they will help to develop their own mineral resources and to utilize them as effectively and economically as possible.

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FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.3.4

Canada

THE USE OF RADIOISOTOPES AND SPECIAL INSTRUMENTATION FOR PROCESS CONTROL AND DEVELOPMENT IN THE MINERAL AND METAL INDUSTRIES

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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THE USE OF RADIOISOTOPES AND SPECIAL INSTRUMENTATION FOR PROCESS CONTROL AND DEVELOPMENT IN THE MINERAL AND METAL INDUSTRIES

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ABSTRACT AND SUMMARY

1. The possible applications of electronic process controls and instrumentation are considered in their relation to development conditions for the metallurgical and mining industries in less-developed areas. In the three phases of resource development--exploration, process development and routine operations--different levels of technical competence are required as well as different degrees of individual responsibility on the part of the operating staff. The greatest field for semi-automatic process control lies in the area of routine plant operations, where it is superior to the alternative of breaking down operations into a large number of simple steps capable of being handled by low-level unskilled labour.

2. The use of radioactive markers and gauges is reviewed and it is seen that, when properly installed, such devices do not differ inherently from other types of process equipment in either complexity or maintenance requirements.

3. The use of radioactive tracers for process development and for the adjustment of operating conditions is valuable in many fields of technology and should be used to the fullest extent wherever experienced supervision is available. Tracer applications are not recommended on a continuous basis in production circuits, unless conditions of recovery of the tracer and total expected radiation levels are exceptional.

4. A brief review is given of recent developments in the use of electronic control equipment in the mineral industries.

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